SPECIFICATION

Electronic Version 1.2.8
Stylesheet Version 1.0

DOUBLE-WALL BLADE FOR A TURBINE, PARTICULARLY FOR AERONAUTICAL APPLICATIONS

Background of Invention

[0001] The present invention relates to a double-wall blade for a turbine, particularly for aeronautical applications.

[0002] As is known, a blade for a gas turbine of an aeronautical engine has an axis which is incident with the axis of the turbine and has a streamlined profile defined by a lateral wall, which, in use, is lapped by gas at a relatively high temperature and must therefore be continually cooled, for example by means of air obtained from a compressor disposed upstream from the turbine, in order to limit firstly the thermal stresses and secondly the mechanical stresses caused by the thermal expansion of the lateral wall itself.

[0003] Blades of the so-called double-wall type are known, in which the lateral wall comprises an outer wall and an inner wall, which are opposite, spaced from and integral with one another.

[0004] The need exists to provide a double-wall blade which, in use, is distinguished by a temperature range which is as regular as possible amongst the various areas of the lateral wall.

[0005] In particular, the need exists to provide a blade which has regular efficiency of heat exchange along the lateral wall, for example by limiting any areas of stagnation of the air which can cool the lateral wall. In addition, the need exists to remove different quantities of heat from amongst the various areas of the lateral wall according to a substantially predetermined map, since it is found experimentally that,

in use, the lateral wall heats up differently from one area to another, in particular along the axis of the blade.

Summary of Invention

[0006] The object of the present invention is to provide a double-wall blade for a turbine, particularly for aeronautical applications, which makes it possible to fulfil the above-described requirements simply and relatively economically.

[0007] According to the present invention, there is provided a double-wall blade for a turbine, particularly for aeronautical applications; the blade comprising a streamlined lateral wall extending along an axis, surrounding said axis, and in turn comprising an inner wall and an outer wall facing and integral with each other; and channeling means for a cooling fluid, comprising an intake cavity for intake of said cooling fluid into said blade, and a number of cooling ducts formed between said inner and said outer wall and tangentially to said inner and said outer wall; characterized in that said cooling ducts are each airtight with respect to an adjacent duct, and have respective intakes separate from one another and communicating with said intake cavity so as to each guide a relative flow of said cooling fluid, which does not mix with the flow in the adjacent duct.

Brief Description of Drawings

[0008] The invention will now be described with reference to the attached drawings, which illustrate a non-limiting embodiment of the invention, in which:

[0009] figure 1 illustrates in transverse cross-section a preferred embodiment of the double-wall blade for a turbine, particularly for aeronautical applications, produced according to the present invention;

[0010] figure 2 illustrates on an enlarged scale and in perspective the blade in figure 1 in cross-section along the line II-II in figure 1;

[0011] figure 3 is a partial view on an enlarged scale of an inner detail of the blade according to the arrow A in figure 1;

[0012]

figure 4 illustrates in perspective and with parts removed for the sake of clarity an

end of the blade in figures 1 and 2;

[0013] figure 5 illustrates in perspective, with parts removed for the sake of clarity and on an enlarged scale, a tail portion of the blade in figures 1 and 2;

[0014] figure 6 illustrates on a highly enlarged scale and with parts removed for the sake of clarity a detail of the blade in figure 2;

[0015] figure 7 is similar to figure 6 and illustrates a variation of the detail in figure 6; and

[0016] figure 8 is similar to figure 1 and shows a further variation of the blade in the above figures.

Detailed Description

[0017] In figures 1 and 2, 1 indicates as a whole a blade, in particular a blade of a stator 2 (illustrated partially and schematically) in an axial gas turbine with variable geometry for an aeronautical engine, to which the following description refers explicitly without detracting from generality. The stator 2 defines an annular duct 3 (partially illustrated), which is provided around the axis of the turbine (not illustrated) and through which, in use, expanding gas at a high temperature passes and which is delimited radially by a pair of platforms 4,5 opposite one another, which support a row of blades 1.

[0018] The blade 1 has its own axis 10 which is incident with the axis of the turbine and comprises two opposite end portions 11, 12, which are coaxial to one another along the axis 10 and are pivoted respectively on the platforms 4 and 5, in order to allow the blade 1 to rotate around the axis 10 itself in order to vary the capacity or geometry of the stator 2, and thus the flow rate of the gases which pass through the stator 2 itself.

[0019] The blade 1 additionally comprises an intermediate axial portion 14, which is integral with the portions 11,12, extends along the axis 10 in the duct 3 and delimits two inner cavities 15,16, which are separated from one another by a wall 17 parallel to the axis 10, and from which the cavity 15 extends along the axis 10 itself and communicates with the exterior via two axial passages 18 provided in the portions

11,12.

[0020] The portion 14 comprises a lateral wall 20 and a pair of end walls 21,22 which are disposed at the opposite axial ends of the lateral wall 20, transverse to the axis 10, delimit the cavity 16 axially and are connected in a sliding manner to the platforms 4 and 5 respectively.

[0021] Again as illustrated in figures 1 and 2, the lateral wall 20 surrounds the axis 10, is lapped in use by the gases which flow in the duct 3 and defines a streamlined profile which has a leading edge 24, a trailing edge 25, and a side or surface 26 which is subjected to pressure and is concave towards the exterior, and a side or surface 27 which is subjected to low pressure, and is convex towards the exterior, which sides extend between the leading edge 24 and the trailing edge 25.

[0022] The blade 1 is of the so-called double-wall type, i.e. the lateral wall 20 comprises an inner wall 28 and an outer wall 29, which face one another and are integral with one another. The walls 28,29 are spaced from one another by a distance which is substantially equal to their thickness, measured along a direction at right-angles to the walls 28,29 themselves, and are connected to one another by a number of baffles 32 disposed on planes which are parallel to one another and at right-angles to the axis 10.

[0023] The baffles 32 separate from one another axially a number of ducts 33, which have the same cross-section of passage, extend around the axis 10 tangentially to the walls 28,29 and constitute part of channeling 34 which also comprises the cavities 15,16 and, in use, can convey cooling air through the blade 1.

[0024]

The baffles 32 are intersected by a baffle 35, which extends axially along the leading edge 24 and projects from the outer wall 29 towards the interior in order to divide the ducts 33 into a number of ducts 36 provided along the side 26 which is subjected to pressure and into a number of ducts 37 which are provided along the side 27 which is subjected to low pressure. The ducts 36,37 have respective intakes 38,39, which are provided in the wall 28 along two rows parallel to the axis 10, communicate with the cavity 15 and are separated from one another by the baffles 35 and 32 in order, in use, to allow a corresponding flow of cooling air which is distinct

from the other flows to pass through each duct 36,37.

[0025] With reference to figures 1 and 3, between the intakes 38,39 and the cavity 15 there is interposed a plate-type element 44, which is connected integrally to the inner wall 28, preferably by means of brazing, and for each intake 38,39 has a corresponding circular through hole 45,46. The cross-sections of passage of the holes 45,46 have respective diameters which differ from one another and are calibrated according to the flow rate of cooling air which is to be made to flow through each duct 36,37.

[0026] With reference to figures 6 and 7, the inner wall 28 and outer wall 29 have respective surfaces 48,49 which are opposite one another in order to delimit the ducts 36,37 and support a number of turbulence generators which can interrupt the final layer of the flow of cooling air along the surfaces 48,49 themselves. These turbulence generators are transverse to a direction S of advance of the flow of cooling air of the duct 33 and are defined according to figure 6 by ribs 51, or according to the variation in figure 7 by incisions 52 provided along the surfaces 48,49.

[0027] As illustrated in figures 1 and 5, each duct 36,37 ends in a corresponding main outlet 54, which is aligned with the duct 36,37 itself and communicates with a slot 55 provided in a tail portion 56 of the blade 1. The slot 55 constitutes part of the channeling 34, is delimited by the end walls 21,22 and by two flat surfaces 58 of the outer wall 29, opens along the outlet edge 25 through a number of ducts 59 and accommodates a number of cylindrical portions or tabs 60, which connect the surfaces 58 to one another.

[0028] As illustrated in figures 1 and 4, each duct 36,37 has a corresponding secondary outlet 61 (figure 1), which is provided through the inner wall 28 in order to open into the cavity 16, whereas the channeling 34 comprises a number of through holes 64 which are provided in the end walls 21,22 and communicate with the cavity 16 in order, in use, to convey the cooling air which is obtained from the outlets 61 and to cool the areas of connection between the end walls 21,22 and the platforms 4,5.

[0029] Figure 8 shows a blade 1a, the component parts of which are indicated, where possible, using the same reference numbers as for blade 1.

[0030] Blade 1a differs from blade 1 by portion 14 comprising, in addition to cavity 15,16, an intermediate chamber 66 separated from cavity 15 by a wall 17, and from cavity 16 by a wall 67 substantially parallel to wall 17.

[0031] As of intakes 38,39, each duct 36,37 comprises a relative first portion 69,70 terminating inside chamber 66 through an outlet 71,72 formed in inner wall 28; and a relative second portion 73,74 which extends from chamber 66 through a relative intake 75,76 formed in inner wall 28, and terminates with outlets 54,61.

[0032] In use, the cooling air, which is obtained for example from a compressor disposed upstream from the turbine, is conveyed in a manner which is known and is not described in detail through a passage 18 in the cavity 15, from which it enters into each duct 36,37 through the corresponding hole 45,46 and the corresponding intake 38,39. In each duct 36, 37 there flows a corresponding flow of cooling air, the flow rate of which is substantially constant and equal to a value which is dependent on the calibrated cross-section of the corresponding hole 45,46, which is established a priori for the same pressure difference between the cavity 15 and the outlets 54,61 and in regular thermal conditions.

[0033] The baffles 32 are therefore formed in one piece with walls 28,29 (figure 2) and transmit heat by means of conduction from the outer wall 29 which is lapped by the gases towards the inner wall 28, whereas the cooling air flows in the ducts 36,37 tangentially to the baffles 32 and to the inner wall 28 and outer wall 29, thus removing heat by convection. The part of the cooling air which flows from the outlets 61 enters into the cavity 16 and passes through the through holes 64 in order to form between the platforms 4,5 and the walls 21,22 a veil of air, which is particularly, but not exclusively suitable for turbines with variable geometry, since, as well as carrying out a cooling function, it prevents the gases from filtering between the platforms 4,5 and the walls 21,22 on the side 26 which is subjected to pressure, towards the side 27 which is subjected to low pressure.

[0034] The part of the cooling air which flows from the outlets 53 flows into the slot 55 tangentially to the surfaces 58 and around the cylindrical portions 60 in order to remove heat by convection from the tail portion 56 until it is output into the duct 3. In particular, the cylindrical portions 60 define respective thermal bridges which transmit

heat by conduction between the surfaces 58.

[0035] It is apparent from the foregoing description that the channeling 34 makes it possible to cool the blade 1,1a such as to obtain a substantially regular range of temperatures along the lateral wall 20.

[0036] In fact, on the one hand, the channeling 34 makes it possible to make flows of cooling air flow along a direction of advance S which is tangential to the baffles 32 and to the walls 28,29, such that the efficiency of heat exchange between the cooling air itself and the lateral wall 20 is relatively high, in particular in comparison with other solutions in which transverse jets of air are provided which cover the lateral wall of the blade.

[0037] At the same time, the efficiency of heat exchange is regular between the various areas of the lateral wall 20, since the ducts 33 have respective intakes and outlets which are different from one another, and thus convey flows of air which are different from one another and are free from localized losses of load or areas of stagnation, caused for example by any elbowed sections, in relation to the flows of air themselves.

[0038] The fact that walls 28,29 are connected integrally by baffles 32 (figure 2) contributes towards making ducts 33 along axis 10 airtight and therefore independent of one another, and permits material continuity between walls 28,29, so that the heat from the gases in duct 3 flows by conduction from outer wall 29 to inner wall 28 in the material interposed axially between ducts 33, the only thermal resistance being the conductivity of the material itself.

[0039] If baffles 32 simply rested on one of walls 28, 29, as opposed to being formed in one piece with walls 28, 29, the heat would encounter greater thermal resistance due to the inevitable, albeit minor, discontinuity of the material of baffles 32 and walls 28,29, thus reducing the amount of heat removed and impairing thermal exchange efficiency.

[0040] In addition, if applicable, the baffles 32 which are transverse to the axis 10 make it possible to differentiate from one another the various flows of air in the ducts 33 along the axis 10.

[0041] In particular, the channeling 34 makes it possible to remove heat according to a substantially predefined map, since it is possible to establish a priori with good approximation the flow rate of the flows of air between the various ducts 36,37, by differentiating the flow rate of these flows both in the direction parallel to the axis 10 and between the side which is subjected to pressure 26 and the side which is subjected to low pressure 27. Thus, for example, it is possible to admit a flow rate of air which is greater in the ducts 36,37 which are provided along the axis 10 approximately halfway along the portion 14 in order to remove a greater quantity of heat from the central portions of the lateral wall 20, which in use are normally subjected to greater heating.

[0042] The flow rate of the flows of cooling air is regulated by the element 44 which can be added in a second stage to the remaining part of the blade 1,1a so as to calibrate the holes 45,46, for example according to the type of aeronautical engine and the position in which the blade 1,1a itself will be fitted.

[0043] The fact of cooling the walls 21,22 also makes it possible to limit the thermal expansions, and thus the mechanical stresses at the areas of connection of the blade 1,1a to the platforms 4,5, whereas the fact of using only the part of the air which is recuperated from the outlets 61 makes it possible not to affect substantially the cooling of the lateral wall 20. This recuperation is extremely simple, owing to the existence of the wall 17, which firstly separates the cavities 15 and 16 from one another in a manner sealed against fluid, and secondly contributes towards strengthening the blade 1.

[0044] The ribs 51, the incisions 52 and the cylindrical portions 60 generate in the flows of cooling air turbulent motion which increases the efficiency of the heat exchange.

[0045] Finally, the construction characteristics of blade 1a enable it to be produced more easily in one piece.

[0046]

Blade 1a, in fact, is produced using a disposable core (not shown) made of ceramic material, in the form of a negative of the material of blade 1a, and comprising an intermediate portion eventually defining chamber 66. By virtue of outlets 71,72 and intakes 75,76, the intermediate portion joins at an intermediate point the lateral

portions of the core eventually defining ducts 36 and 37, so that the core is easier to produce and stronger than the one required for blade 1, and the lateral portions of the ducts of which are joined slely at the ends, i.e. at intakes 38,39 and outlets 54,61.

[0047] Finally it is apparent from the foregoing description that modifications and variations which do not depart from the field of protection of the present invention can be made to the blade 1,1a described and illustrated.

[0048] In particular, the ducts 33 could have arrangements different from that indicated by way of example, provided that they are transverse to the axis 10, and or dimensions different from those indicated by way of example. In addition, the ducts 33 could have cross-sections of passage with dimensions which differ from one another in order to have flow rates of air passing through them which differ from one another.

[0049] In addition, cylindrical portions or tabs similar to the cylindrical portions 60 could also be provided in the ducts 33.

[0050] Finally, the channeling 34 could also be provided in a fixed stator blade or in a rotor blade.